# Section 2
# Lakes Assessment

## St. Lawrence River

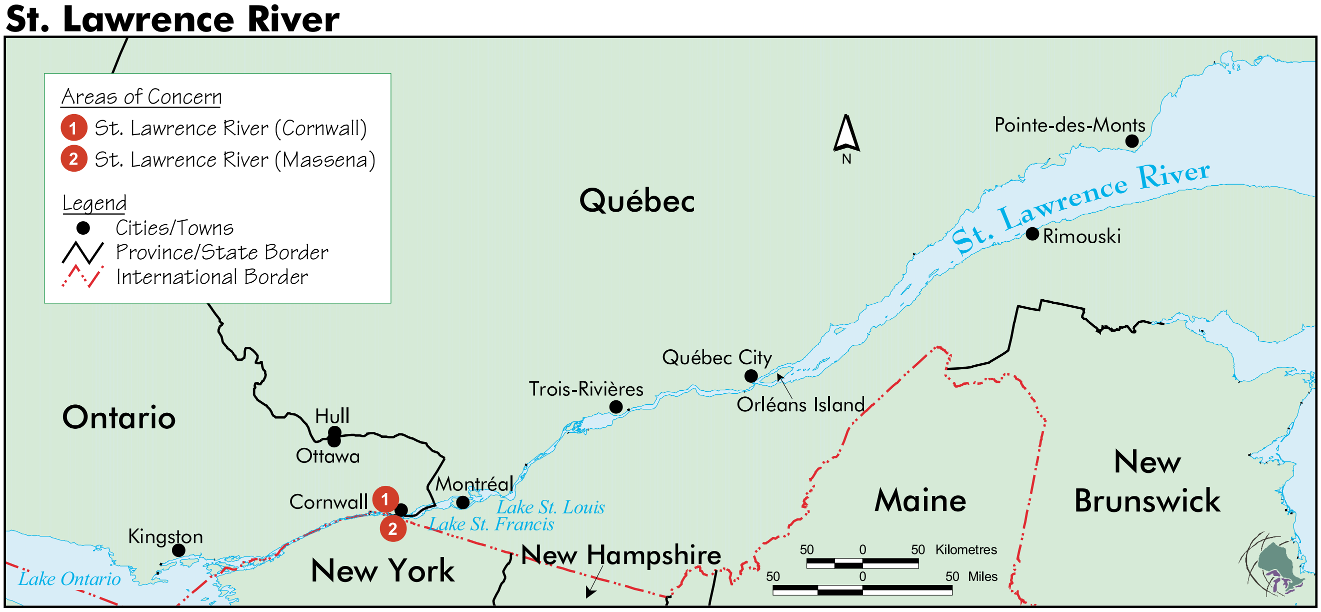
### State of Biodiversity and Aquatic Non-Native Species

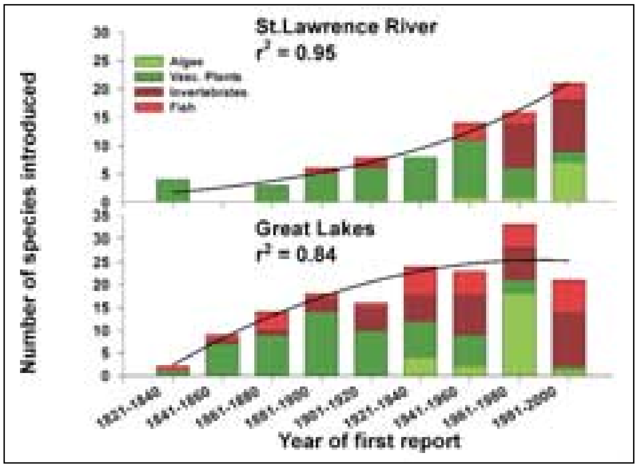
*The status of biodiversity in the St. Lawrence River is **mixed-deteriorating** because of continued habitat loss and the introduction of aquatic non-native species.*

The recently released Biodiversity Portrait of the St. Lawrence River (http://www.qc.ec.gc.ca/fauna/biodiver/) has emphasized the loss of wetlands as one of the major factors affecting the integrity of the River ecosystem. The amplitude of annual water level fluctuations has decreased following the opening of the St. Lawrence Seaway, reducing the diversity of wetland flora and affecting fish populations that depend upon flooded wetlands for spawning. Approximately 50% of the St. Lawrence River shoreline has been modified by agriculture and urbanization. Erosion is a concern along 25% of the shoreline. The result is the loss of both terrestrial and aquatic natural habitats. For example, more than 1,500 hectares of island habitats have been lost since 1950. Still more important losses are predicted if River flows decline because of climate change.

Although habitat loss is having an impact on the St. Lawrence freshwater fish community, aquatic non-native species introductions to the River may be a more serious threat. To aid in developing a conservation strategy for the St. Lawrence River ecosystem, aquatic non-native species introductions are now being studied by Environment Canada. A list of introduced aquatic species is being compiled, the transfer of species between the Great Lakes and the River is being evaluated, and the spatial distribution and temporal trend of introduced species is being assessed using available literature and databases.

**St. Lawrence River**






Trends in species introductions since 1820.
Source: St. Lawrence Centre-Environment Canada

Recent information indicates a continuing upward trend in aquatic non-native species introductions to the St. Lawrence River with an average rate of one species per year. Approximately 50% of the aquatic non-native species introduced to the Great Lakes have been reported in the St. Lawrence River. Upstream transfer of species from the River to the Lakes is also a source of species introductions to the Great Lakes. However, the problem of non-native species introductions to the St. Lawrence River is due primarily to downstream transfer from the Great Lakes. The percent of species transferred has increased with time, and is expected to remain high over the next decade considering that close to half the species introduced in the Great Lakes have not yet reached the River.

The conclusions regarding biodiversity and aquatic non-native species in the St. Lawrence River are that:

- Despite important habitat losses and modifications, further losses are anticipated as a result of climatic changes that will certainly affect the biodiversity of the River;
- There are insufficient data to assess or predict the potential impact of non-native species in the river;
- The information on aquatic non-native species presence and their distribution need to be validated;
- Guidelines for ship ballast exchange should be rigorously applied and compliance should be enforced for the St. Lawrence River; and
- Overall, the biodiversity of the St. Lawrence River is under considerable stress.

**St. Lawrence River Statistics**

| | |
|---|---|
| **Elevation** | Kingston<br>246 ft. 75 m<br>Lake St. Francis<br>151 ft. 46 m<br>Lake St. Louis<br>66 ft. 20 m<br>Montreal<br>18 ft. 5.5 m |
| **Length** | |
| miles | 599 |
| kilometers | 964 [a] |
| **Mean Annual Discharge** | |
| ft.$^3$/s | 44,965 |
| m$^3$/s | 12,600 [b] |
| **Land Drainage Area** | |
| sq. mi. | 78,090 |
| km$^2$ | 204,842 [c] |
| **Water Surface Area** | |
| sq. mi. | 6,593 |
| km$^2$ | 17,077 [d] |
| **Shoreline Length** | North Shore<br>305 mi. 490 km<br>South Shore<br>280 mi. 450 km |
| **Transient Time** | |
| hours (minimum) | 100 [e] |
| **Outlet** | Gulf of St. Lawrence |

[a] Length of 964 km is from Kingston to Pointe-des-Monts
[b] The mean annual discharge of 12,600 m$^3$/s is at Quebec City Level
[c] The land drainage area of 204,842 km$^2$ represents the freshwater section in the Quebec Region (Cornwall to Orléans Island)
[d] Total water surface from Cornwall to Pointe-des-Monts
[e] The transient time applies to Quebec and does not include New York State and Ontario

Source: The River at a Glance, Environment Canada - Quebec Region

# Lake Ontario

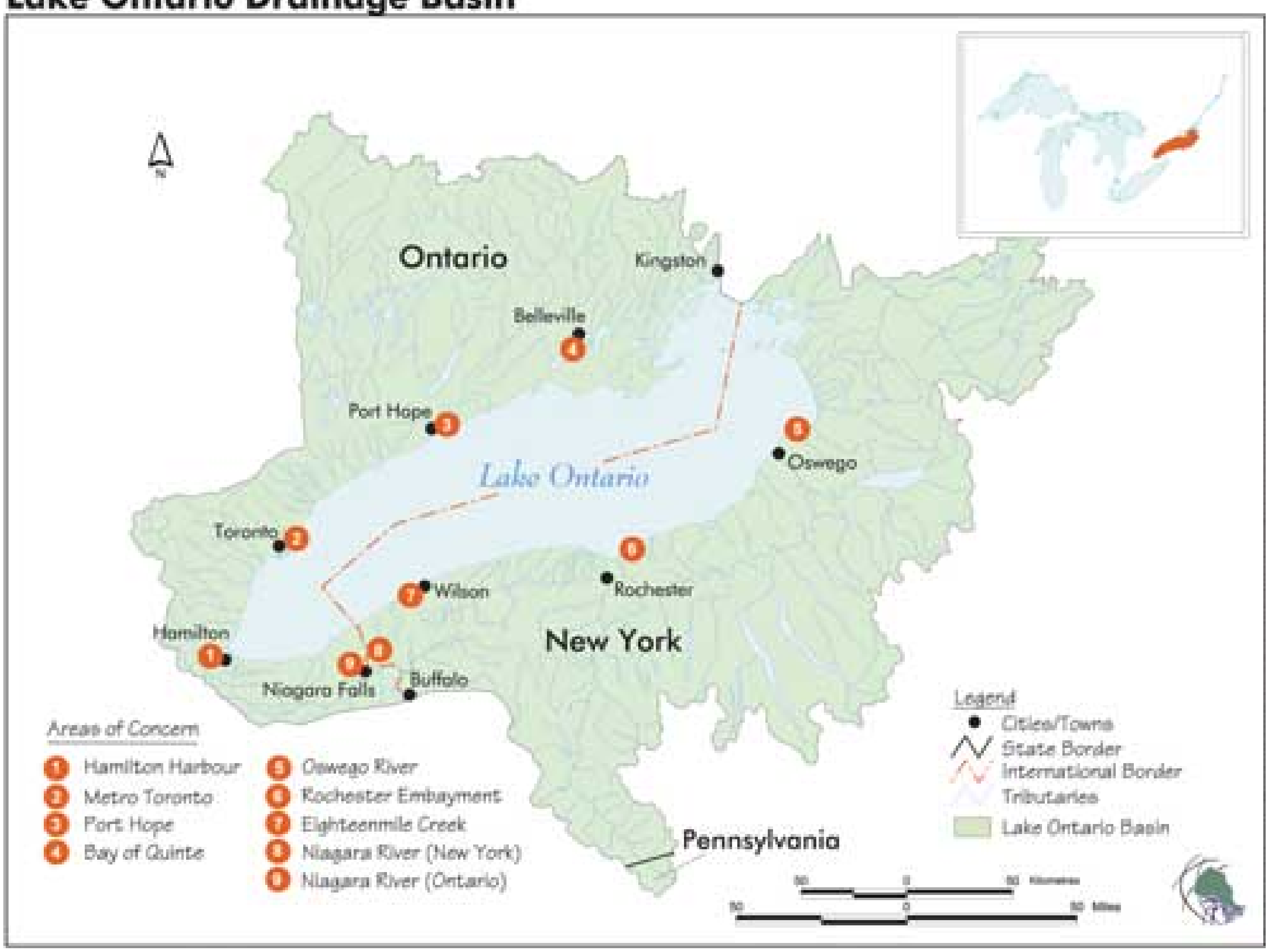
## State of Lake Trout

*The status of Lake Ontario lake trout is* ***mixed*** *because of recent increases in wild young-of-the-year juveniles, but also because of decreased survival of stocked lake trout, no increase in wild fish abundance, a diet consisting mostly of alewives, and early mortality syndrome.*

Lake trout is native to all five lakes. It is a top predator that requires oligotrophic (low nutrient levels) conditions and clean spawning substrate. It has a long life span, is genetically diverse, and integrates many ecosystem components. The dominant dietary item is the alewife. The paradox is that the alewives prey on lake trout fry and are probably linked with Early Mortality Syndrome. The Syndrome is caused by thiamine (vitamin B1) deficiency. The management dilemma is that the prey species that supports an economically valuable fishery inhibits the survival of lake trout and other native species.

Native lake trout have been extirpated (eliminated) from all of the Great Lakes except Superior. Four stressors contributed to the extirpation: over-fishing as early as the nineteenth century; habitat loss from development and agriculture; non-native invasive species such as the sea lamprey; and, contamination of fish by dioxin-like chemicals beginning in the 1930s and peaking in the late 1960s. Contamination levels may have been high enough for 100% mortality of

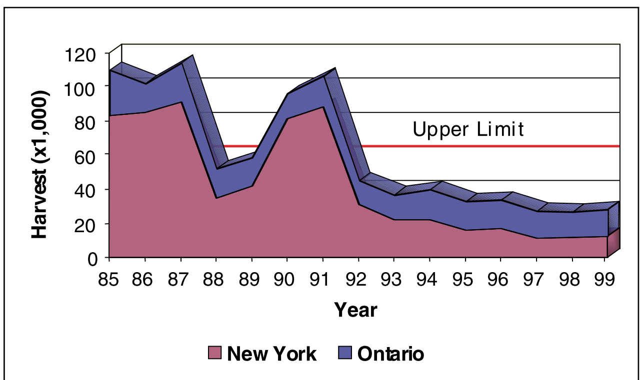
**Lake Ontario Drainage Basin**



young fish (fry) from 1945 to 1975. After 1991, levels were below the threshold for adverse effects.

Fishery management agencies for Lake Ontario have established a goal of rehabilitating the lake trout population such that, "The adult spawning stock(s) encompasses several year classes, sustains itself at a relatively stable level by natural reproduction, and produces a usable annual surplus (harvest)."

On the positive side, natural reproduction of lake trout has occurred in Lake Ontario since 1985. The proportion of older fish has increased since 1994, while the average age of mature females has been increasing. Fishing mortality remains low. The distribution of naturally produced fish has been widespread throughout the lake, and recent information from the U.S. side of Lake Ontario indicates that numbers of wild lake trout young-of-the-year increased in the spring of 2001. The sea lamprey control program has been effective and lamprey are under control.




Lake trout sport harvest, Lake Ontario.

Source: New York State Department of Environmental Conservation, and Ontario Ministry of Natural Resources

On the negative side, there is decreased survival of stocked lake trout, there has been no increase in total numbers of wild fish, lake trout diet consists mostly of alewives, and early mortality syndrome is still a problem.

The keys to the future success of lake trout rehabilitation in Lake Ontario include improved survival of stocked lake trout; diversification of diet; continued effective sea lamprey control; habitat protection; restrictive angling regulations; and continued low contaminant levels.

Beyond lake trout rehabilitation work, the Lakewide Management Plan for Lake Ontario proposes three categories of ecosystem indicators: 1) critical pollutant indicators including open water, young-of-the-year fish, herring gull eggs, and lake trout; 2) lower food web biological indicators including nutrients, zooplankton, and preyfish; and, 3) upper food web biological indicators including herring gull, lake trout, mink and otter, and bald eagle.

**Lake Ontario Statistics**

| | |
|---|---|
| **Elevation**[a] | |
| feet | 243 |
| metres | 74 |
| **Length** | |
| miles | 193 |
| kilometers | 311 |
| **Breadth** | |
| miles | 53 |
| kilometers | 85 |
| **Average Depth**[a] | |
| feet | 283 |
| metres | 86 |
| **Maximum Depth**[a] | |
| feet | 802 |
| metres | 244 |
| **Volume**[a] | |
| cu. mi. | 393 |
| $km^3$ | 1,640 |
| **Water Area** | |
| sq. mi. | 7,340 |
| $km^2$ | 18,960 |
| **Land Drainage Area**[b] | |
| sq. mi. | 24,720 |
| $km^2$ | 64,030 |
| **Total Area** | |
| sq. mi. | 32,060 |
| $km^2$ | 82,990 |
| **Shoreline Length**[c] | |
| miles | 712 |
| kilometres | 1,146 |
| **Retention Time** | |
| years | 6 |
| **Population:** | |
| **USA (1990)†** | 2,704,284 |
| **Canada (1991)** | 5,446,611 |
| **Totals** | 8,150,895 |
| **Outlet** | St. Lawrence River |

[a] measured at low water datum
[b] Lake Ontario includes the Niagara River
[c] including islands
† 1990-1991 population census data were collected on different watershed boundaries and are not directly comparable to previous years

Source: The Great Lakes: An Environmental Atlas and Resource Book

# Lake Erie

## A Changing Ecosystem

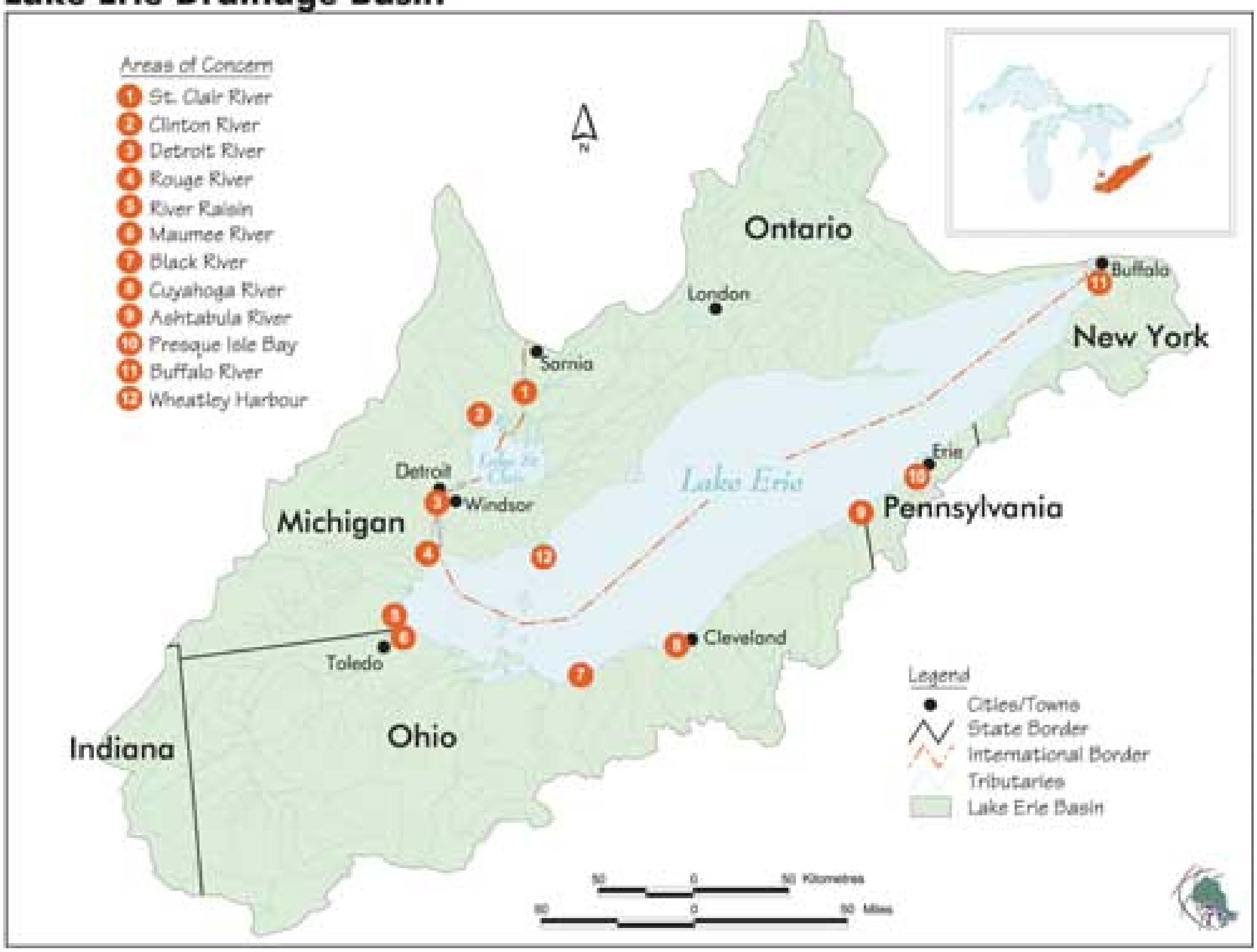
*The status of Lake Erie is **mixed** to **mixed-deteriorating** because of continued aquatic non-native species impacts, habitat loss or alteration, and contamination by toxic chemicals.*

One-third of the human population of the Great Lakes basin lives in the intensively urbanized and agricultural Lake Erie watershed. In addition to providing drinking water for 11 million people, Lake Erie is used for many purposes, including industrial, recreational, municipal and agricultural. Issues and concerns affecting the health of the Lake Erie ecosystem include continued contamination of fish and wildlife by toxic chemicals, increasing nutrient levels, an influx of aquatic non-native species, and continued habitat loss.

### Contaminants

The chemicals of concern include toxic substances (PCBs, chlordane, DDT and metabolites, dioxins, dieldrin, PAHs, agricultural pesticides, endocrine disruptors), heavy metals (lead, mercury), and nutrients (phosphorus, nitrates). For example, although PCBs in Lake Erie sediments decreased from 1971 to 1995, there are still high concentrations in the Western Basin despite contaminant reductions.

**Lake Erie Drainage Basin**



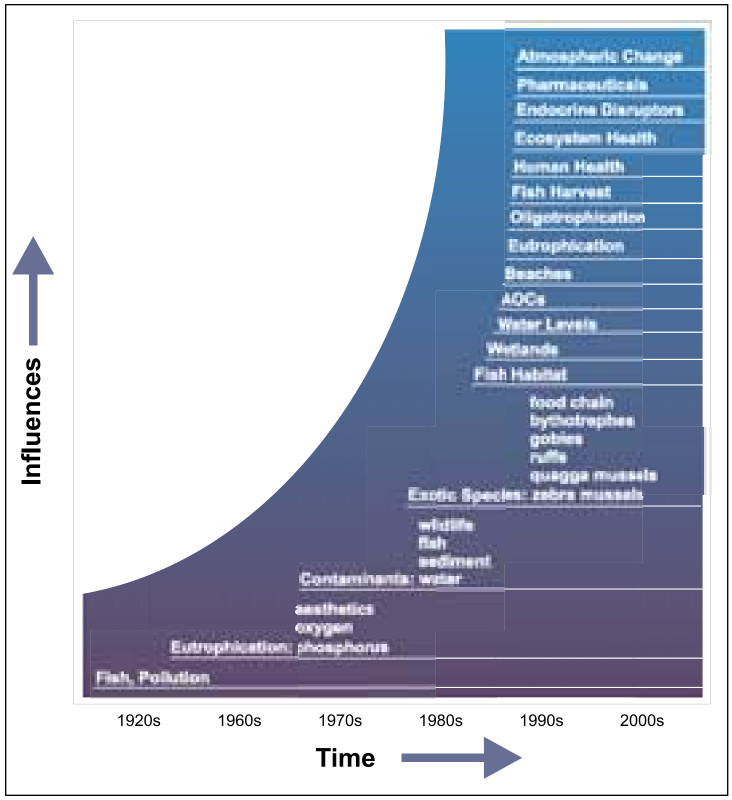
| Lake Erie Statistics | |
|---|---|
| **Elevation**[a] | |
| feet | 569 |
| metres | 173 |
| **Length** | |
| miles | 241 |
| kilometers | 388 |
| **Breadth** | |
| miles | 57 |
| kilometers | 92 |
| **Average Depth**[a] | |
| feet | 62 |
| metres | 12 |
| **Maximum Depth**[a] | |
| feet | 210 |
| metres | 64 |
| **Volume**[a] | |
| cu. mi. | 116 |
| $km^3$ | 484 |
| **Water Area** | |
| sq. mi. | 9,910 |
| $km^2$ | 25,700 |
| **Land Drainage Area**[b] | |
| sq. mi. | 30,140 |
| $km^2$ | 78,000 |
| **Total Area** | |
| sq. mi. | 40,050 |
| $km^2$ | 103,700 |
| **Shoreline Length**[c] | |
| miles | 871 |
| kilometres | 1,402 |
| **Retention Time** | |
| years | 2.6 |
| **Population:** | |
| **USA (1990)†** | 10,017,530 |
| **Canada (1991)** | 1,664,639 |
| **Totals** | 11,682,169 |
| **Outlet** | Niagara River Welland Canal |

[a] measured at low water datum
[b] Lake Erie includes the St. Clair-Detroit system
[c] including islands
† 1990-1991 population census data were collected on different watershed boundaries and are not directly comparable to previous years

Source: The Great Lakes: An Environmental Atlas and Resource Book

### Nutrients

Although significant reductions in the annual loadings of phosphorus to Lake Erie has been achieved since the early 1970s, concentrations of phosphorus in the Western and Central Basins still regularly exceed the target levels derived from the Great Lakes Water Quality Agreement. In addition, the concentration of nitrates in the Eastern and Western Basins has increased since the early 1980s, possibly affecting amphibians and reptiles.




Influences on the Lake Erie ecosystem through time.
Source: Environment Canada

### Non-native Species

Aquatic non-native species such as zebra mussels, the round goby, purple loosestrife, and the fishhook water flea (*Cercopagis*) are continuing to disrupt the food web. Zebra mussel grazing in particular appears to be altering community structure. The abundance of phytoplankton in the Eastern Basin is less than predicted from phosphorus concentrations in the water, and *Microcystis* (a type of blue green alga) blooms have appeared in the Western Basin. Populations of large, cold water species of zooplankton have been reduced, and zebra mussel larvae and the spiny waterflea (*Bythotrephes*) are replacing native zooplankton populations.

### Fisheries

Walleye and yellow perch populations are declining, while lake whitefish harvest is increasing.

### Habitat

Lake Erie basin natural habitats are continuing to degrade, including wetlands, forests, sand beaches, dunes and barrens, lakeplain prairies, as well as tributaries and the open lake. Emerging issues such as climate change will add to existing problems as will continued human population growth.

The ability to monitor and track changes in the Lake Erie ecosystem has been diminished because ecosystem changes are occurring rapidly, and because resources for monitoring are declining. Research is needed to understand changes in the ecosystem.

## St. Clair River - Lake St. Clair - Detroit River Corridor

*The status of the St. Clair River - Lake St. Clair - Detroit River Corridor is **mixed** because of fish consumption advisories, historical and current wetland losses, a degraded benthos, contaminated sediments, exceedances in water quality standards, beach closures, and problems with drinking water; but contaminants are generally below problem levels and there have been incremental gains in habitat protection and restoration.*

The corridor consists of the St. Clair and Detroit Rivers, and Lake St. Clair. The major population centres are Port Huron, Michigan; Sarnia, Ontario; Detroit, Michigan; and Windsor, Ontario. The population centres are also industrial centres. The Michigan side of the corridor is largely populated, with wetland areas remaining on the north side of Lake St. Clair. The Ontario side is agricultural. Walpole Island, which is First Nations territory, has superb tallgrass prairie, wetland, and oak savanna habitats.

### The St. Clair - Detroit Corridor


Lake St. Clair was surrounded primarily by wetlands prior to European settlement, and although these wetlands are considerably smaller today, Lake St. Clair is still habitat for a diverse fishery. Recreational boating and fishing are of great economic importance in the region. There are currently about 200 marinas and 150,000 boats in Michigan alone, with an annual value to the economy of approximately $260 million. More than 1.5 million fish are taken from Lake St. Clair annually, accounting for nearly half of the entire Great Lakes sport fishing industry.

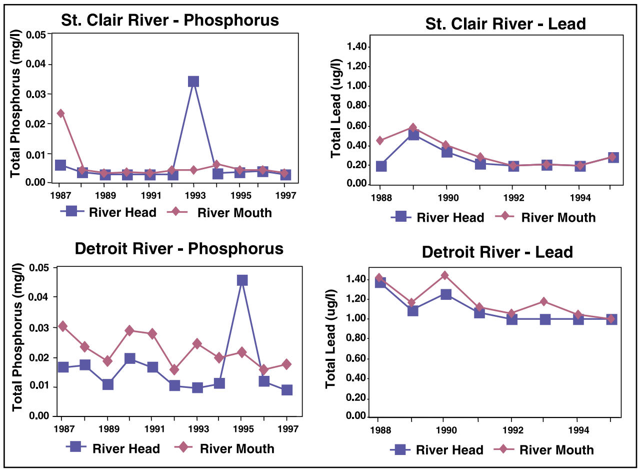
The issues or problems that indicate the health of the Corridor is degraded are: fish consumption advisories, historical and current wetland losses, a degraded benthos, contaminated sediments, exceedances of water quality standards and guidelines, beach closures, and problems with drinking water.

In the St. Clair River, lead and chloride levels have decreased. Phosphorus levels increased in the mid-1990s but are now leveling off. Levels of copper are constant, but zinc levels have been rising.

In Lake St. Clair, chloride levels are constant. Mercury levels in the edible portion of walleye have decreased significantly, PCB levels increased in 2000 after a steady decline. HCB and OCS levels in channel catfish have declined.

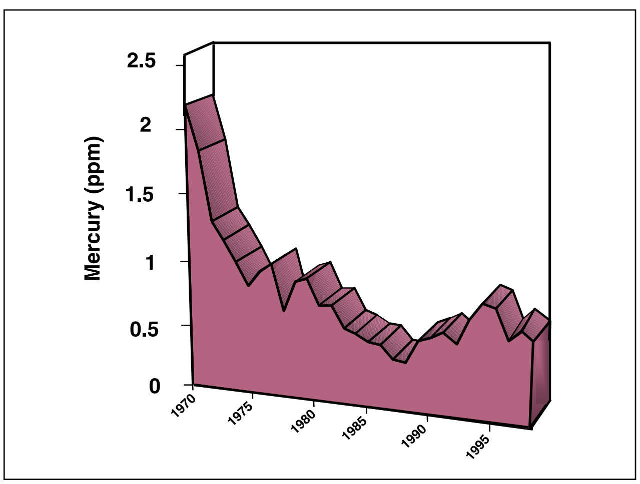
In the Detroit River, lead has decreased, while chloride has increased slightly at the head of the river. Levels of copper and zinc are constant.

Historic coastal wetland losses in the Corridor were severe. However, since the early 1980s, the total area of protected and restored wetlands has increased. In the last two




Comparison of phosphorus and lead levels at St. Clair and Detroit Rivers.

Source: Ontario Ministry of Environment and Environment Canada




Mercury levels in Lake St. Clair walleye.

Source: Environment Canada

decades, more than 500 hectares in the St. Clair River, 3000 hectares in Lake St. Clair, and 500 hectares in the Detroit River have been protected or restored.

Spills to the St. Clair and Detroit Rivers have decreased considerably since 1986. Water quality has shown a marked improvement.

Loss of fish and wildlife habitat is a primary and consistent concern throughout the Corridor. Current activities to mitigate habitat loss are:

- Critical habitat acquisition;
- Shoreline enhancement;
- Development of a biodiversity conservation strategy and atlas;
- Identification of candidate sites for protection and rehabilitation; and
- Protection of designated wetlands.

In conclusion, the Corridor is important ecologically and commercially. Current needs are:

- Effective source controls for current contamination and better management of historical contamination;
- Focus on habitat protection and restoration with a view toward incremental gains; and
- Ongoing monitoring to ensure continuous improvement.

**Lake St. Clair Statistics**

| | |
|---|---|
| **Elevation** | |
| feet | 569 |
| metres | 173 |
| **Length** | |
| miles | 26 |
| kilometers | 42 |
| **Mean Breadth** | |
| miles | 24 |
| kilometres | 39 |
| **Mean Depth** | |
| feet | 11 |
| metres | 3.4 |
| **Mean Annual Discharge** | |
| ft.$^3$/s | 183,000 [a] |
| m$^3$/s | 5,182 [a] |
| **Maximum Depth (natural)** | |
| feet | 21 |
| metres | 6.5 |
| **Watershed Area** | |
| sq. mi. | 460 |
| km$^2$ | 1,191 |
| **Land Drainage Area** | |
| sq. mi. | 6,100 [b] |
| km$^2$ | 5,799 [b] |
| **Water Surface Area** | |
| sq. mi. | 400 [c] |
| km$^2$ | 1,036 [c] |
| **Shoreline Length** | |
| miles | 62 |
| kilometres | 100 |

[a] Inflow into Lake St. Clair
[b] Land areas include the total drainage area to the outlet of the upstream lake
[c] Water Surface Area does not include area of connecting channels

Source: Lake St. Clair: Its Current State and Future Prospects, Lake St. Clair Network, United States Geological Survey

# Lake Huron

## The Lake in the Middle

*The status of Lake Huron is* ***mixed*** *because, despite gains in terms of point source controls and progress in Areas of Concern, there are still stresses attributed to large atmospheric inputs of contaminants; hardened shorelines; and continued threats from non-native species.*

Lake Huron is often called "the lake in the middle" due to its position in the Great Lakes and the view that the level of pollution is somewhere between "pristine" Lake Superior and Lake Ontario. In spite of its "middle" status, Lake Huron is interesting and unique. Lake Huron has over 30,000 islands, more than any other lake in the world. The largest, Manitoulin, is the largest island in a freshwater lake. If the shorelines of the islands are included, Lake Huron has the longest lakeshore of any lake in the world as well. More than 2.5 million people live in the basin, mostly in the southern portion. Historical pollution discharges, particularly in Sarnia, Ontario and Saginaw Bay, Michigan, have caused serious problems in a number of areas in the basin, including the designation of five Areas of Concern. The five Areas are the St. Marys River, Spanish River, Saginaw River and Bay, Severn Sound, and the St. Clair River. Current activities, including industry and seasonal land use development, are putting increasing pressures on wildlife habitats and unique ecosystems.

Critical pollutants have been identified and include PCBs, chlordane, dioxins, mercury,

**Lake Huron Drainage Basin**

**Lake Huron Statistics**

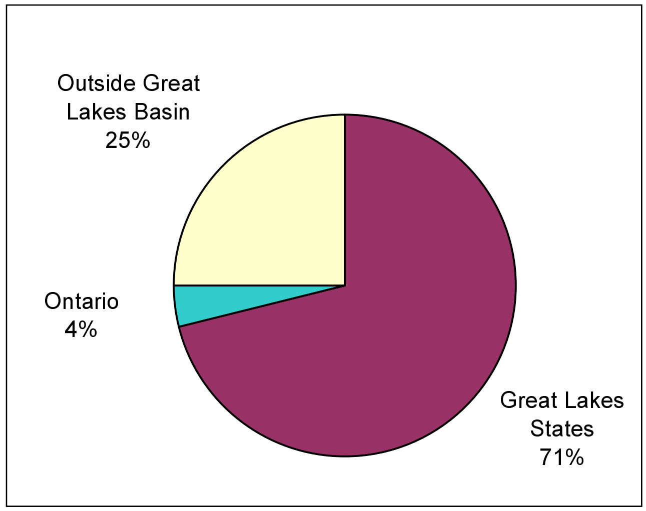
| | |
|---|---|
| **Elevation**[a] | |
| feet | 577 |
| metres | 176 |
| **Length** | |
| miles | 206 |
| kilometers | 332 |
| **Breadth** | |
| miles | 183 |
| kilometers | 245 |
| **Average Depth**[a] | |
| feet | 195 |
| metres | 59 |
| **Maximum Depth**[a] | |
| feet | 750 |
| metres | 229 |
| **Volume**[a] | |
| cu. mi. | 850 |
| $km^3$ | 3,540 |
| **Water Area** | |
| sq. mi. | 23,000 |
| $km^2$ | 59,600 |
| **Land Drainage Area**[b] | |
| sq. mi. | 51,700 |
| $km^2$ | 134,100 |
| **Total Area** | |
| sq. mi. | 74,700 |
| $km^2$ | 193,700 |
| **Shoreline Length**[c] | |
| miles | 3,827 |
| kilometres | 6,157 |
| **Retention Time** | |
| years | 22 |
| **Population:** | |
| **USA (1990)†** | 1,502,687 |
| **Canada (1991)** | 1,191,467 |
| **Totals** | 2,694,154 |
| **Outlet** | St. Clair River |

[a] measured at low water datum
[b] land drainage area for Lake Huron includes St. Marys River
[c] including islands
† 1990-1991 population census data were collected on different watershed boundaries and are not directly comparable to previous years

Source: The Great Lakes: An Environmental Atlas and Resource Book

sediment/suspended solids, and DDT. Concentrations of PCBs in whole lake trout have declined significantly since 1978, but are still above the protection values for fish-eating birds and mammals. There has been no significant decline in PCBs or mercury since the mid-1980s. Continuing sources may include historical discharges and air deposition. The rate of decrease for contaminant trends in fish eating birds has slowed. Most bird populations have become re-established, but some reproductive problems persist. Bald eagle populations continue to grow, with interior breeding areas having greater productivity than nearshore ones. Loadings from water sources are the lowest of the Great Lakes, but air sources are the highest. About 80%-90% of dioxins are from atmospheric sources. Contaminated sediments in the Areas of Concern and out-of-basin atmospheric deposition must be addressed to deal with critical pollutant issues.

Nearshore terrestrial ecosystems still sustain a great diversity of wildlife. They sustain important habitats as food sources for fish and wildlife. Saginaw Bay continues to provide essential habitat,




Sources of atmospheric deposition of dioxin to Lake Huron, 1999.

Source: Great Lakes Trends: Into the New Millennium, Office of the Great Lakes, Michigan Department of Environmental Quality

but a continued loss of wetlands is a serious threat. Critical stresses include degradation and loss of historical tributary and nearshore habitats, the introduction of non-native species, over-fishing, and fish and wildlife reproductive failure.

The Lake Huron fisheries goals are:

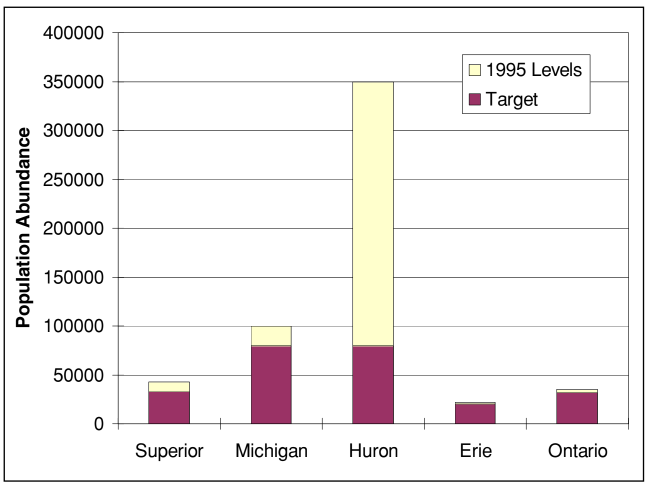
- to protect and enhance existing habitats and rehabilitate degraded habitats;
- to achieve no net loss of the productive capacity of habitats;
- to restore damaged habitats; and
- to support the reduction of contaminants.

However, there are several fishery concerns such as the dependence on hatchery production, the impact of non-native species on fish communities, and the insufficient rate of lake trout reproduction, as well as those concerns discussed in the following paragraphs.

One fishery concern is that historically, tributaries were important sources of cool, high quality water serving as spawning and nursery habitat. The construction of dams has excluded fish from many tributaries. This is a deterrent to achieving balanced fish communities because tributaries are now inadequate habitat for all life cycle stages. Dams now fragment many streams where historical spawning occurred.

A second fishery concern is nearshore habitat. Many nearshore areas have been altered with shoreline protection structures. In many areas, the band of transition vegetation has disappeared. The cumulative impact of these structures is significant and increasing in regard to the fishery.

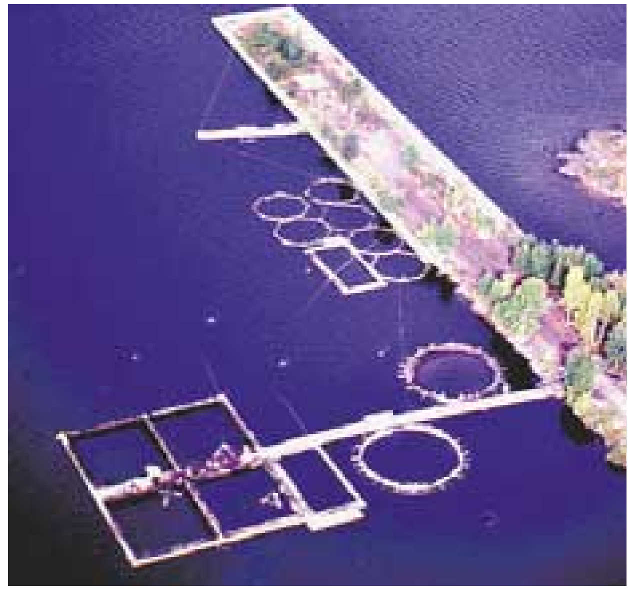
A third concern is the loss of coastal wetlands. Most current coastal wetland losses have been around small urban centres on the lakeshore. Losses are due to agriculture, cottage development, road construction, dredging, and channelization.




Sea lamprey populations and targets.
Source: Great Lakes Fishery Commission

A fourth fishery concern is the significant stress to aquatic communities caused by non-native species. Species that are having a great impact are the sea lamprey, zebra mussel, ruffe, round goby, and purple loosestrife. The sea lamprey problem is associated with production in the St. Marys River and is the most severe impediment to a healthy fish community. Cost effective sea lamprey control on the river may be within reach. The sea lamprey population is expected to be reduced by 85% by 2010.

Finally, aquaculture is a growing fishery concern. Fish farms now account for over 60% of rainbow trout production in the Ontario waters of Lake Huron.



Aquaculture pens near Parry Sound, Georgian Bay.
Source: Ontario Ministry of Natural Resources

The following actions are still needed to improve the Lake Huron ecosystem:

- Control atmospheric inputs of persistent toxic substances;
- Initiate an aquatic nuisance species control program beyond the sea lamprey control program;
- Continue progress in Areas of Concern;
- Implement watershed management plans;
- Fully fund the lamprey control program;
- Encourage local protection and restoration efforts;
- Research lower trophic levels; and
- Control pathogen sources (Saginaw Bay and southeast Lake Huron).

# Lake Michigan

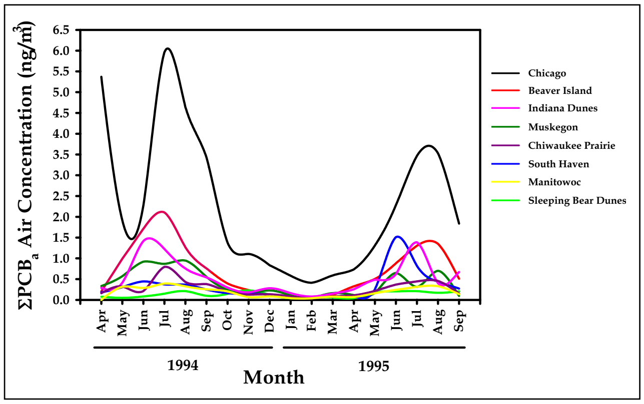
## State of the Fishery

*The status of Lake Michigan is* ***mixed*** *because of continued impairments and only slight improvement towards the goals established by the Lakewide Management Plan. The status of progress toward achieving Lake Michigan fish community objectives is as follows: fish population structures–mixed/improving; restoration or protection of fish habitat–mixed/deteriorating; prevention or control of aquatic nuisance species–mixed.*

Lake Michigan is an outstanding natural resource of global significance, but it is under stress and in need of special attention. It is the second largest lake by volume and has the world's largest collection of freshwater sand dunes. It has approximately 40% of all the Great Lakes coastal wetlands and more than 26% of the prime waterfowl. It also has ten Areas of Concern in various stages of cleanup.

The sources of continuing contamination to the lake include atmospheric deposition, tributaries, and historic sediment deposition. The southern-most end of the lake has the highest concentrations of PCBs, with the PCB loadings for the lake primarily from the atmosphere at 1536 kilograms (3386 pounds) per year. Atmospheric mercury and atrazine loadings, in large part deposited by rain and snow, are 729 and 1694 kilograms per year respectively (1607 and 3735

Lake Michigan Drainage Basin




Atmospheric concentration of PCB over Lake Michigan.

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office

pounds respectively). PCB loadings (1994 data) from major monitored tributaries are greatest from the Fox River, Grand Calumet Harbor, and Kalamazoo River. According to 1995 data, atrazine loadings are greatest from the Fox, St. Joseph, Pere Marquette, and Kalamazoo Rivers. Mercury loadings (1995 data) are greatest from the Fox, Grand, Kalamazoo, and St. Joseph Rivers.

The fish community goal for Lake Michigan is to restore and maintain the biological integrity of the fish community so that production of desirable fish is sustainable and ecologically efficient. For preyfish species, the objective is to maintain a diversity of preyfish species at population levels matched to primary production and to predator demands. Expectations are for a lakewide preyfish biomass of 0.5 to 0.8 billion kilograms (1.2 to 1.7 billion pounds). However the abundance of benthos (bottom organisms) at 40 sites in Lake Michigan's southern basin has shown a decline in bottom life, likely linked to the introduction of zebra mussels. The dominant species, *Diporeia*, is eaten by a variety of Great Lakes fish and is an important component of the Lake Michigan food web. Another component of the forage base, bloater chub, alewife, and rainbow smelt has also declined since the early 1990s.

For salmon and lake trout, the objective is to establish a diverse harvest of 2.7 to 6.8 million kilograms (6 to 15 million pounds) of which 20-25% is lake trout. Another objective is to establish self-sustaining lake trout populations. Lakewide trout and salmon harvests have dropped since the mid-1980s.

For bottom feeders, the objective is to maintain self-sustaining stocks of lake whitefish, round whitefish, sturgeon, suckers, and burbot. The expected annual yield of lake whitefish alone should be 1.8 - 2.7 million kilograms (4 to 6 million pounds), but for 1999, the lakewide harvest of all these fish was about 3.2 million kilograms (7 million pounds).

The goal of inshore fish stocks is to maintain self-sustaining stocks of yellow perch, walleye, smallmouth bass, pike, catfish, and panfish. Expected annual yields should be 0.9 to 1.8 million kilograms (2 to 4 million pounds) for yellow perch and 0.1 to 0.2 million kilograms (0.2 to 0.4 million pounds) for walleye. In 1999, the lakewide yellow perch harvest was about 272,000 kilograms (600,000 pounds), a steady decline from the mid to late 1980s. The lakewide walleye harvest was just under 68,000 kilograms (150,000 pounds), or at about the same level since 1985.

Other fish community objectives include protecting and sustaining a diverse community of native species, including other species not specifically mentioned earlier such as gars and bowfin. These

## Lake Michigan Statistics

| | |
|---|---|
| **Elevation**[a] | |
| feet | 577 |
| metres | 176 |
| **Length** | |
| miles | 307 |
| kilometers | 494 |
| **Breadth** | |
| miles | 118 |
| kilometers | 190 |
| **Average Depth**[a] | |
| feet | 279 |
| metres | 85 |
| **Maximum Depth**[a] | |
| feet | 925 |
| metres | 282 |
| **Volume**[a] | |
| cu. mi. | 1,180 |
| $km^3$ | 4,920 |
| **Water Area** | |
| sq. mi. | 22,300 |
| $km^2$ | 57,800 |
| **Land Drainage Area** | |
| sq. mi. | 45,600 |
| $km^2$ | 118,000 |
| **Total Area** | |
| sq. mi. | 67,900 |
| $km^2$ | 175,800 |
| **Shoreline Length**[b] | |
| miles | 1,638 |
| kilometres | 2,633 |
| **Retention Time** | |
| years | 99 |
| **Population: USA (1990)†** | 10,057,026 |
| **Outlet** | Strait of Mackinac |

[a] measured at low water datum
[b] including islands
† 1990-1991 population census data were collected on different watershed boundaries and are not directly comparable to previous years

Source: The Great Lakes: An Environmental Atlas and Resource Book

species contribute to the biological integrity of the fish community and should be recognized and protected for their ecological significance and cultural and economic values. Another fish community objective is to suppress the sea lamprey to allow the achievement of other fish community objectives.

In conclusion, progress toward achieving fish community objectives is mixed/improving for fish population structures; mixed/deteriorating for the restoration and protection of fish habitat; and mixed for the prevention/control of aquatic nuisance species. To protect and enhance fish habitat and rehabilitate degraded habitats, it will be necessary to achieve a "no net loss" of the productive capacity of habitat supporting Lake Michigan's fish communities. High priority should be given to the restoration and enhancement of historic riverine spawning and nursery areas for anadromous species.

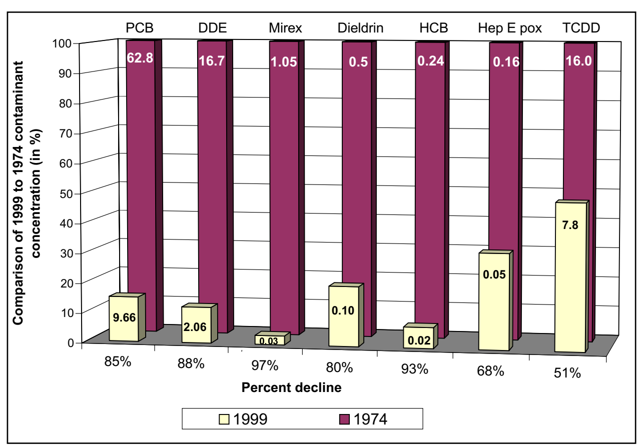
# Lake Superior

## State of the Ecosystem

*The status of the Lake Superior basin ecosystem is* ***mixed*** *because of: poor offshore chub populations; mixed (some gains and some losses) in terms of continued fish consumption advisories, the status of herring gull populations, critical pollutant reductions, atmospheric deposition, human population change, quantity of water consumed; mixed/improving for lake trout nearshore, all habitats for lake herring, sea lamprey abundance; and good for lake trout offshore habitat and lake whitefish nearshore.*

Lake Superior's aquatic communities are closest to what the communities of the Great Lakes must have been like prior to European settlement. The status of these aquatic communities is measured by two indicators: fish abundance, including lake trout, chubs, lake herring, and whitefish, and sea lamprey abundance.

The trend in catch for lean and Siscowet lake trout in commercial fisheries from 1950 to 1998 has not changed for lean trout and is upward with fluctuations for Siscowet trout. Catch per unit effort for lake herring is declining while the chub fishery is almost non-existent. Lake whitefish catch per unit effort for both gill net and trap net has risen over the last decades. Sea lamprey has declined since the 1950s with a slight rise in 1999.




Contaminants in herring gull eggs, Lake Superior, 1974 vs. 1999 data.

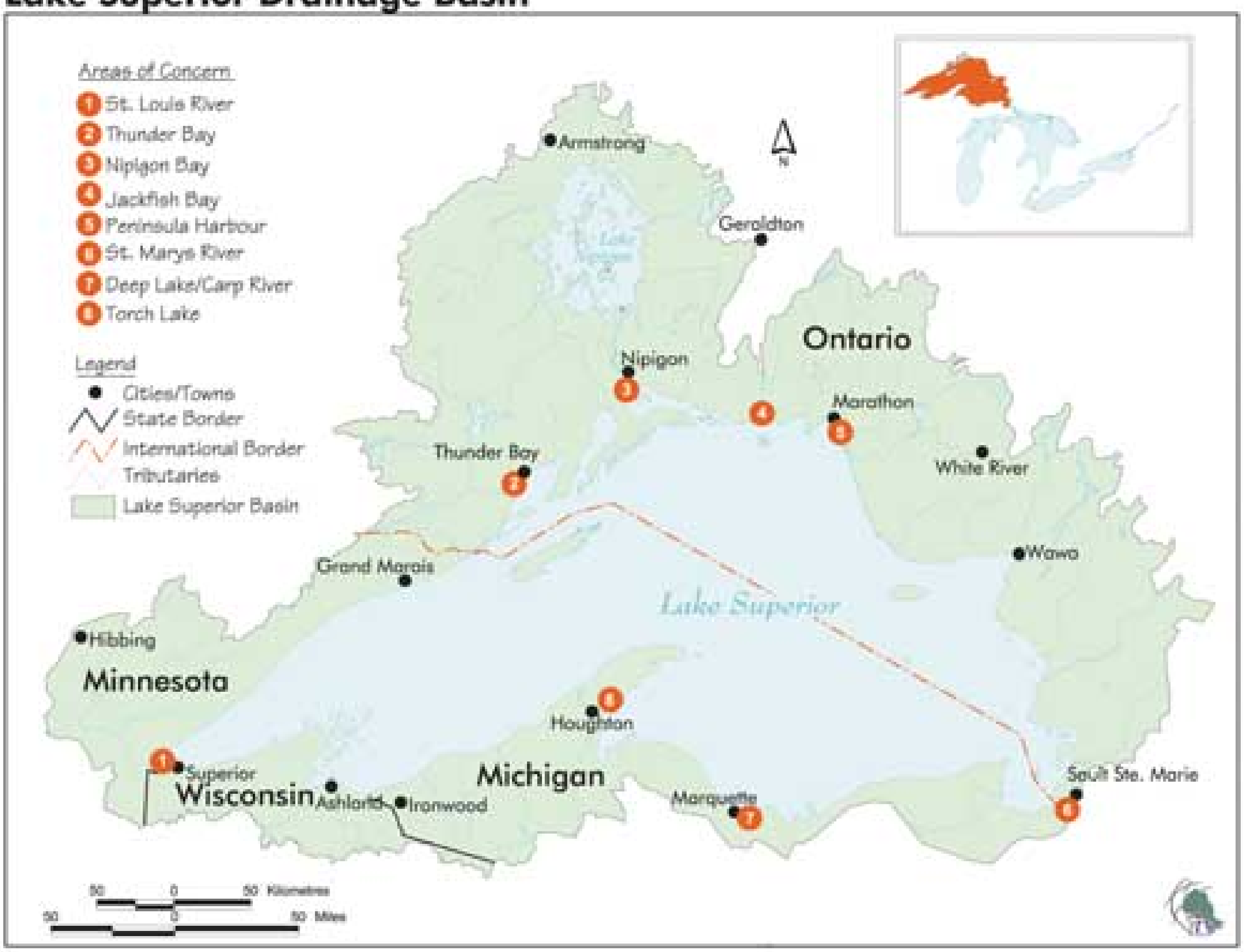
Source: Environment Canada

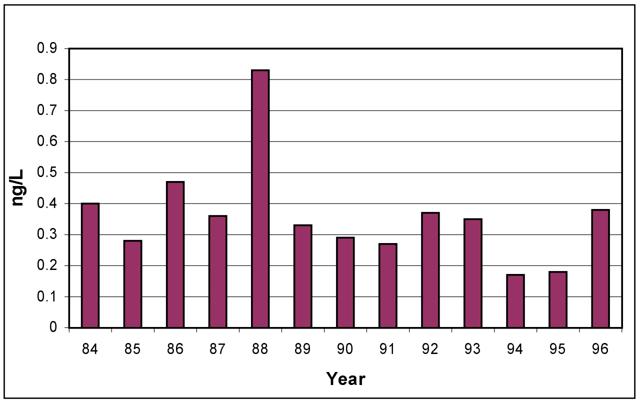
Wildlife community indicators are forest breeding birds, with trends unique to the local environment, and colonial waterbirds, where herring gulls are indicators of regional contaminant levels. Herring gull contaminants–PCBs, DDE, mirex, dieldrin, HCB, heptachlor-epoxide, and TCDD–have declined from 51% to 97% since 1974. Herring gull abundance, measured in number of breeding pairs and number of colonies, has nearly doubled in Canada between 1976 and 1999. In the United States, numbers have increased only slightly, from 7,106 pairs to 7,715 and from 90 colonies to 134.

Progress toward the management goal of zero discharge of emissions of nine critical pollutants is mixed. The mercury goal for 2000 has been met. But meeting the 2010 milestones will require strategies relating to fuel combustion and mining. Mercury emissions from sources in the Lake Superior basin have decreased to about 1,000 kilograms per year. Open lake concentrations of most toxic chemicals are lower than the most sensitive guidelines, except for dieldrin at 0.114 ng/L; PCBs at 0.0705 per ng/L; and toxaphene at 0.9 and 0.7 ng/L. PCBs in Chinook salmon (0.3 ppm) are still well above the unlimited consumption level of 0.05 ppm.

One Lakewide Management Plan objective is the virtual elimination of atmospheric emissions of toxic chemicals of human origin from the lake. Atmospheric deposition is the dominant pathway for critical pollutants. Atmospheric loadings will continue for an unknown length of time.

## Lake Superior Drainage Basin






Dieldrin trends in Lake Superior precipitation.
Source: Environment Canada

Indicators of how well humans are being sustained by the landscape are related to use of ecosystem resources, trends in human population density and municipal water use. Data from Ontario show a relatively stable population base and a stable per capita residential water use.

Lake Superior emerging issues are numerous and include: introduction of non-native species, airborne pollutants, human migration into the basin, habitat fragmentation, meeting zero-discharge milestones, exposure and effects of chemical mixtures, endocrine disrupting chemicals, mercury, new chemicals, and domestic use of burn barrels. The Lake Superior Binational Program's initial focus has been on the Zero Discharge Demonstration Program. In 1997, the Program broadened to incorporate six ecosystem themes in its charge. Active public participation was sought through the Binational Forum. Project implementation is underway during 2000 to 2002.

**Lake Superior Statistics**

| | |
|---|---|
| **Elevation**[a] | |
| feet | 600 |
| metres | 183 |
| **Length** | |
| miles | 350 |
| kilometers | 563 |
| **Breadth** | |
| miles | 160 |
| kilometers | 257 |
| **Average Depth**[a] | |
| feet | 483 |
| metres | 147 |
| **Maximum Depth**[a] | |
| feet | 1,332 |
| metres | 406 |
| **Volume**[a] | |
| cu. mi. | 2,900 |
| $km^3$ | 12,100 |
| **Water Area** | |
| sq. mi. | 31,700 |
| $km^2$ | 82,100 |
| **Land Drainage Area** | |
| sq. mi. | 49,300 |
| $km^2$ | 127,700 |
| **Total Area** | |
| sq. mi. | 81,000 |
| $km^2$ | 209,800 |
| **Shoreline Length**[b] | |
| miles | 2,729 |
| kilometres | 4,385 |
| **Retention Time** | |
| years | 191 |
| **Population:** | |
| **USA (1990)†** | 425,548 |
| **Canada (1991)** | 181,573 |
| **Totals** | 607,121 |
| **Outlet** | St. Marys River |

[a] measured at low water datum
[b] including islands
† 1990-1991 population census data were collected on different watershed boundaries and are not directly comparable to previous years

Source: The Great Lakes: An Environmental Atlas and Resource Book